Non-Transcranial Electroanesthesia

Group 2
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Advisors: Doctor Paul King and Doctor James Berry

Project Definition

- Design, build, and test a system for both administering and recording data related to vagal nerve stimulation.

- Topics to cover: Project Background, Design Ideas, Stimulation (production and application) Techniques, Testing, Overall Status, Current Status, and Key Issues
Project Background

- Advisor: Dr. James Berry (Dept. of Anesthesiology Multi-Specialty Division)
- Computer Engineering expertise from Dr. Andrew Dozier (Dept. of Electrical/Computer Engineering)

Currently, electroanesthesia devices are in use in Europe.

In less developed countries where anesthesia technology is lacking, an electroanesthesia device would reduce both the cost of the procedure and the need for technical personnel (anesthesiologist).

- S. Leduc --> Europe, Japan, Russia, and Germany
- Activation of a theoretical pain center
  - 35 V, 4 mA, 100 Hz, rectangular pulsating signal
- Alternative method
  - Descending mechanism and the interconnections within the brain
Background: Electroanesthesia

- Quicker recovery time and less biological effect during and after surgery (Photiades, 218-225)
- Heal better (Sances and Larson, 21-27)
- Less a build up of gases in the body (Sances and Larson, 218-219)
- EEG and ECG
- Electrolyte levels in extracellular and intracellular fluid of the brain (Sances and Larson, 148-175)
- Decreased gastric acid secretion (Sances and Larson, 33-46)
- FDA
- Kano et al. (1976)
- Vagal Nerve Stimulation (Kirchner et al., Ness et al.)

Background: Nerve Information

**Vagal Nerve**
- 10th cranial nerve
- Location: both sides of the neck
- Composition: A, B, and C-fibers
- Function: motor and sensory (visceral afferent) signals
- C-fibers and Pain
- Not fully myelinated until adulthood (Koo et al. 429-433)
- Shown to help control seizures and depression
- Best Route to the Central Nervous System Rutecki (1990)

**Facial Nerve**
- 7th cranial nerve
- Location: both sides of the head by the ear
- Composition: Branches of fibers
- Function: motor and sensory signals
- Facial Expression
- Myelinated
- NO research into therapeutic use
- Does lead into the Central Nervous System
Background: Vagal Nerve Fiber Information

- **A-fibers**
  - Adapt to constant stimulus and exhibit presynaptic inhibition
  - Respond well to low stimulus (George et al. s56-s61)
  - Conduction Speed: 90 to 30 m/s
  - Selectively activated by low intensity VNS
  - No effect on EEG recorded in the rats studied by Hammond et al. (1992)
- **B-fibers**
  - Respond well to low stimulus (George et al. s56-s61)
  - Conduction Speed: 20 to 10 m/s
  - No effect on EEG recorded in the rats studied by Hammond et al. (1992)
- **C-fibers**
  - Continue to fire with constant stimulus
  - Conduction Speed: 1.6 to .3 m/s

Methods

- **Computer system**
- **Vital signs monitoring equipment**
- **Testing**
  - **Phase I:**
    - Device components connected and tested to assure compatibility
    - Software integrated and tested to assure compatibility and proper operation
    - Test inputs and outputs of device
  - **Phase II:** Applicator testing to assure proper outputs and operation
  - **Phase III:** Testing of device operation with a rat
Design 1

- Too Complex
- Un-needed components

Design 2

- Less Components Needed
- Laptop keyboard eliminates need for an additional keyboard
- Internal components dependent on stimulation method
**Cost**

- Gas anesthesia
  - In the case of gas anesthesia, more is required for treatment and cost are around twenty to forty dollars a patient (Kurpiers et. al., 69-75).
- Liquids
  - between three and nine times as expensive as gas anesthesia per volume (Kurpiers et. al., 69-75).
- Electroanesthesia will reduce the high cost of anesthesia for surgery and other procedures by reducing the need to keep large quantities of liquid and gas anesthesia on hand.

**Stimulation Parameters**

- Stimulation of both Vagal Nerves
- 20 Hz Rectangular pulse signal
- Pulse length of 250 µs (Liporace et al. 885-886)
- 50 µA (Kirchner et al. 1167-1171)
- 25 V
- Need to consult more with Dr. Berry to estimate best parameters
Soundcard

- Virtins Sound Card Signal Generator

LabVIEW

- LabVIEW user interface
- DAQ controller

Expensive to actually buy DAQ controller
Delivering Electroanesthesia

- Option 1: Cortical Stimulator (Ojemann Cortical Stimulator)
  - Advantage: Add gain stage
  - Disadvantage: Knobs not computer compatible, gain stage
Delivering Electroanesthesia

- Option 2: Gain Stage
  - Advantage: Computer compatible
  - Disadvantage: Noise, unforeseen circuitry problems

Recent Contacts

- Ray Booker - Simulation engineer at Ctr. for Medical Simulation
  - Discussed head and neck phantoms
    - Cost
    - Availability
    - Function
Sim-man

- Most expensive and limited funds (NEGATIVE)
- Not immediately available (NEGATIVE)
- Possible damage from device (NEGATIVE)

Airway Model

- Relatively inexpensive (POSITIVE)
- Immediately available (POSITIVE)
- Thin, plastic head and neck (NEGATIVE)
- No damage from electric shock (POSITIVE)
Plaster Cast

- Inexpensive (POSITIVE)
- Can be made and remade whenever needed (POSITIVE)
- Dimensions somewhat flexible (POSITIVE)

Current Status

- Sent out NCIIA report before winter break
- Laptop for project given by Dr. Berry and started programming in LabView
- Applied to BMEidea
- Divided tasks among group members
- Consulted Ray Booker for test subjects and materials
- Assigned weekly meeting times
Overall Status

<table>
<thead>
<tr>
<th>Month</th>
<th>Description</th>
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<tbody>
<tr>
<td>November 2004</td>
<td>Look into previous research done on VNS and Electroanesthesia. Develop schematics and possible device physical designs. Start design development.</td>
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<tr>
<td>December 2004</td>
<td>Proceed with research and finalize our design approach. Assemble basic design components. Develop software and user interface.</td>
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<tr>
<td>January 2005</td>
<td>Begin designing prototype model and testing.</td>
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<tr>
<td>February 2005</td>
<td>Proceed with prototype design and testing. Obtain IRB approval to test our device.</td>
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<tr>
<td>March 2005</td>
<td>Run experiments if approved and make modifications where necessary. Continue work-up and finalize design.</td>
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<tr>
<td>April 2005</td>
<td>Continue to finalize Design and prepare paper and presentation poster.</td>
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Most Important References